Overview of Treatment, Completion, and Workover Fluids (TCW)

OOC briefing to EPA Region 6 /4

Dallas, TX

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Overview

- Environmental Regulation Overview
  - Water Discharge and Waste Disposal
- TCW Operational Definitions
- TCW Categories
  - Category I Fluids
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- Questions

Environmental Regulations: Offshore Operations Overview

Offshore well treatment, completion, and workover operations are governed by existing regulations and / or permits:

- Air Emissions – regulated by BOEM through Air Quality Reviews or EPA via PSD / Title V regulations
- Water Discharges – regulated by EPA through NPDES permits
- Wastes – regulated by EPA, DOT, and states

Water Discharges

- How Regulated?
  - EPA NPDES Permits
- In GoM, EPA has authority for permitting discharges to water under the NPDES program:
  - EPA Regions 4 (Eastern GoM) and 6 (Central & Western GoM)
  - Each region has issued a NPDES General permit for their area of the GoM (# GEG460000 and GMG290000, respectively)
  - Permits, in place since the 1990s, are renewed every five years to incorporate changes to requirements, initiate joint industry studies (JIPS) and the like
  - Permits contain specific testing requirements & limits for discharges associated with well treatment / completion / workover (TCW) operations

Waste Disposal

- How Regulated?
  - EPA RCRA and Solid Waste regulations
  - DOT / State waste transportation regulations
  - State waste testing & disposal regulations
- If well TCW fluids do not meet NPDES discharge criteria, they are shipped to shore for disposal or recycle / reuse under the above regulations.
  - Discharges must meet an oil and grease daily maximum limitation of 42 mg/l and a monthly average limitation of 29 mg/l
  - No free oil as measured using the static sheen test method
  - No priority pollutants except in trace amounts

TCW Operational Definitions

- Treatment fluid - Any fluid used to remediate a well performance issue after a well has been drilled
  - May be composed of categories I-IV below
- Completion fluid - Any fluid used in completing a new well
  - Typically composed of category I below and rarely category IV
- Workover fluid - Any fluid used in the workover/recompletion/ or abandonment of an existing well
  - Typically composed of category I below, rarely category IV
- TCW fluids have significant overlaps and may consist of:
  I. Fresh Water, Sea Water, and Salt Water Brines of Variable Density
  II. Organic & Inorganic Acid and Non-reactive fluid systems
  III. Hydraulic fracturing fluids- (typically formulated from category I fluids)
  IV. Hydrocarbon based fluids

What Are Category I Fluids?

- Typically clear brine based fluids used to treat, complete, or work over a well
  - Compatible with the formation, tubular goods, elastomers
  - Can be designed for long-term stability in the wellbore (packer fluids)
  - Can be formulated into non-reactive fluid systems
  - Can be formulated into fracturing fluid
- May be comprised of:
  - Fresh water or sea water
  - Salt water brines of appropriate density for well control
    - (Also called clear brine fluids)

Category I Fluid Properties
Fresh & Brine Water-Based TCW Fluids

- Why do we use brines?
  - Clear brine fluids give us density control without solids (like in drilling mud)
  - Reduce damage to productive well intervals while still maintaining well control
- Fresh water weighs ~ 8.33 pounds per gallon (ppg) @ room temp.
- Sea water has approximately 3.5% salinity (mostly sodium chloride) and weighs 8.55 ppg @ room temp.
- Various salts may be mixed with fresh water (depends on required density)
  - Sodium chloride max density is ~ 10.0 ppg @ room temp.
  - Calcium chloride max density is ~ 11.8 ppg @ room temp.
  - Sodium bromide max density is ~ 12.7 ppg @ room temp.
  - Calcium bromide max density is ~ 15.3 ppg @ room temp.
  - Zinc bromide max density is ~ 21.0 ppg @ room temp.
  - All salts above may be blended in varying combinations to obtain different properties under various conditions of pressure and temperature

Category I Fluid Formulations

- Typically comprised of one or more of the fluids listed on the previous slide:
  - Primary design factor is density (required for well control)
  - Secondary design factors are:
    - Compatibility to the formation, reservoir fluids, tubulars and elastomers
    - Significant testing is accomplished to formulate blends that meet all requirements
  - Final fluid formulation provides the proper density for well control and is compatible with well equipment, reservoir fluids and reservoir conditions.
  - Completion fluids are typically referred to as “clear brine fluids” indicating that they are free of solids (which can damage the reservoir).

Category II Fluids

- Organic & Inorganic Acids and/or blends of each
  - Always used as a treating fluid to remediate some form of damage in a well
  - Always inhibited to protect tubular goods, (elastomer compatibility is also checked)
  - Typically acetic & formic (organic) acids and hydrochloric & hydrofluoric (inorganic) acids are most commonly used
- Typically used to:
  - Remove scale damage
  - Improve permeability of sandstone and carbonate reservoirs and alleviate near-wellbore damage
  - Always a treatment fluid

Category III Fluids

- Fracturing fluids typically use a Category I fluid as the base component
  - Small amounts of Polymers such as guar are used to give the fluid viscosity
  - Cross-linkers like boron are used to create a "Jell-O" like fluid consistency
    - Supporting additives are used to improve the cross-link function above, or improve performance of the fracturing fluid:
      - Buffers maintain favorable frac fluid pH to stabilize the cross-link
      - Surfactants improve wettability of the reservoir and fluid recovery
      - Breakers insure that the cross-link breaks as designed
  - Always a treatment fluid
  - Additives make up less than 5% of total fluid composition

Typical Fracturing Fluid Formulation (1000 gals) (1000 gal = 24 bbls)		
Additive Name	Additive Quantity	Unit of Measure
Fresh Water	985	gallons
Salt (3% KCl)	250	pounds
Polymer- guar	20 – 40	pounds
Buffer	1 – 5	gallons
Surfactant	1 – 5	gallons
Cross-linker	1 – 3	gallons
Breaker	1 – 2	pounds

Category III Example Volumes

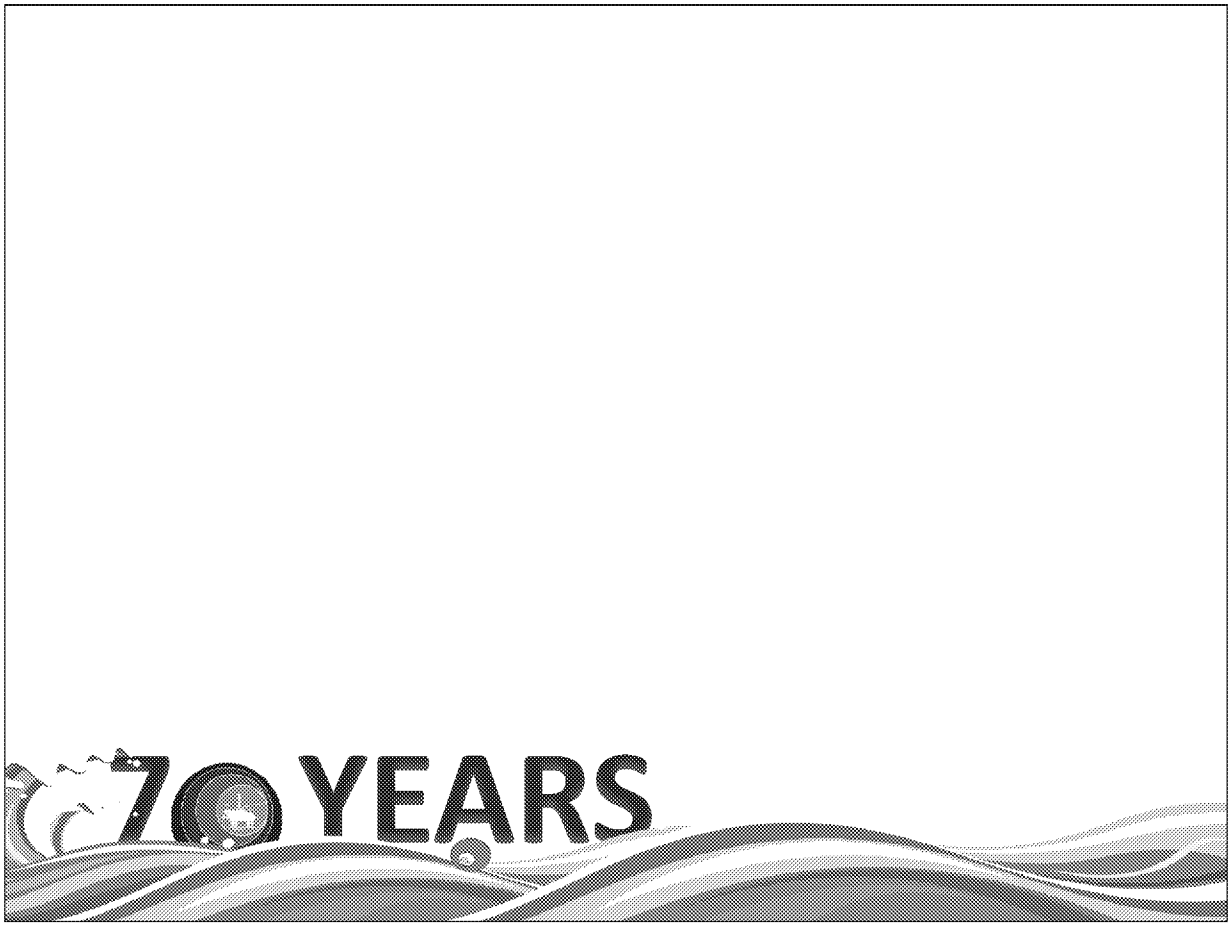
FRAC STAGE TYPE	TYPICAL VOLUME PUMPED (bbls/stage) UNCONSOLIDATED FORMATION FRAC PACK	TYPICAL VOLUME PUMPED (bbls/stage) CONSOLIDATED FORMATION FRAC
Misc Fluids / Workstring Volumes	1,500 – 7,000	1,500 – 7,000
Mini-Frac	500 - 700	500 - 700
Mini-Frac Flush	500 - 800	500 - 800
Main Treatment	1,500 – 2,500	5,000 – 7,000
Main Treatment Flush	500 - 800	500 - 800

Note: Typical pumped volumes denote representative volumes used in each respective environment
Typical recovery volumes range from 10% - 30%. The remainder stays in the formation.

Category IV Fluids

- Can be classified as either a treatment, completion, or workover fluid depending on how it is used
- The use of hydrocarbon-based fluids in TCW fluids is infrequent and is normally limited to the removal of waxes & asphaltenes from the wellbore and/or sand-face
- Some hydrocarbons can be gelled to act as fracturing fluids, but that is only when water-based fluids are extremely damaging to the reservoir and not common in the offshore environment
- Gelled hydrocarbons may also be used as packer fluids to control convective heat transfer in wells that have high bottom hole temperatures or high flow rates that create a high-temperature environment that could damage ancillary equipment
- Base oils can be used to perform negative testing for regulatory compliance

Questions?


70 YEARS